April 30, 2003. Claims 1-25 are pending in this application. Claims 1-25 were considered and stand rejected. Applicants cancel claims 21 and 23 without prejudice. Applicants submit new claims 26-29 for consideration by the Examiner. Applicants believe that no new matter has been introduced in this response.

Paragraphs **[0019]** and **[0024]** have been amended. Support for amendment of paragraph **[0019]** is found, for example, in paragraphs **[0037]** and **[0041]**. Support for amendment of paragraph **[0024]** is found, for example, in paragraph **[0025]**.

Claims 1, 8, and 22 were objected to by the Examiner. Claims 1, 8, and 22, have been amended to correct informalities. Applicants respectfully request withdrawal of the objection.

Claims 1-12 are rejected under 35 U.S.C. § 102(b) as being anticipated by, or rejected under 35 U.S.C. § 103(a) as being unpatentable over, *Yau et al.* (Patent No. 6,054,379). The Examiner asserts that *Yau et al.* discloses or suggests the subject-matter as recited in claims 1-12 by Applicants. Applicants respectfully respond to this rejection.

*Yau et al.* discloses depositing a low dielectric contact film by reaction of an organo silane compound and an oxidizing gas. The oxidized organosilane film may be used a liner layer, a cap layer, an etch stop, or an intermetal dielectric layer.

*Yau et al.* does not teach, show, or suggest depositing a barrier layer on the substrate by introducing a processing gas comprising an organosilicon compound into a processing chamber, wherein the organosilicon compound has the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 1 or 2, b is 1 or 2, and c is 1 or 2, and reacting the processing gas to deposit the barrier layer, wherein the barrier layer has a dielectric constant less than 4 and depositing a first dielectric layer adjacent the barrier layer, wherein the dielectric layer comprises silicon, oxygen, and carbon and has a dielectric constant of about 3 or less, as recited in claim 1, and claims dependent thereon.

Applicants also assert that the recited claims are drawn to unexpected and surprising results over prior art. The surprising and unexpected results are derived from depositing barrier layers from organosilicon compounds as recited in the claims to produced a silicon carbide film having a dielectric constant of less than 4 with improved barrier layer properties, such as an interlayer diffusion resistance of about 100% greater

than silicon carbide film produced by commercially available alkylsilane precursors, such as trimethylsilane (TMS). This is unexpected because it has been observed that phenyl groups increase the porosity of the deposited dielectric material, thereby reducing the interlayer diffusion resistance of the deposited dielectric material.

Examples provided at paragraphs **[0059] – [0062]** of the specification indicate a significant and unexpected improvement in barrier layer properties and dielectric constant for alkyl substituted phenylsilane compounds in comparison to available barrier layer processes. Comparison data of diphenylmethylsilane and simethylphenylsilane deposited silicon carbide films showing significant improvement over trimethylsilane deposited silicon carbide films is provided as follows:

diphenylmethylsilane deposited silicon carbide films were observed to have a measured dielectric constant of about 3.6, a leakage current of about $3e^{-9}$ amps/cm$^2$ at 1 MV/cm and about $4e^{-8}$ amps/cm$^2$ at 2 MV/cm, and had a 50% failure rate after about 10 hours;

dimethylphenylsilane deposited silicon carbide films were observed to have a measured dielectric constant of about 3.5, a leakage current of about $1e^{-9}$ amps/cm$^2$ at 1 MV/cm and about $2e^{-8}$ amps/cm$^2$ at 2 MV/cm, and had a 50% failure rate after about 11 hours; and

trimethylsilane deposited silicon carbide films were observed to have a measured dielectric constant of about 4.3, a leakage current of about $1e^{-09}$ amps/cm$^2$ at 1 MV/cm and about $1e^{-6}$ amps/cm$^2$ at 2 MV/cm and had a 50% failure rate after about 4.4 hours.

Withdrawal of the rejection of claims 1-~~13~~ 12 is respectfully requested.

Claims 13-25 are rejected under 35 U.S.C. § 102(b) as being anticipated by, or rejected under 35 U.S.C. § 103(a) as being unpatentable over, *Yau et al.* (Patent No. 6,054,379). The Examiner asserts that *Yau et al.* discloses or suggests the subject-matter as recited in claims 13-25 by Applicants. Applicants respectfully respond to this rejection.

*Yau et al.* is described above. *Yau et al.* does not teach, show, or suggest depositing a barrier layer on the substrate by introducing a processing gas comprising an organosilicon compound into a processing chamber, wherein the organosilicon compound has the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 1 or 2, b is 1 or 2, and c is 1

or 2, and an oxygen-containing compound, a nitrogen-containing compound, or combinations thereof, and generating a plasma to deposit the barrier layer, wherein the barrier layer has a dielectric constant of less than 4 and depositing a dielectric layer adjacent the barrier layer, wherein the dielectric layer has a dielectric constant less than 4., as recited in claim 13, and claims dependent thereon.

The prior art made of record is noted. However, it is believed that the secondary references are no more pertinent to the Applicants' disclosure than the primary references cited in the office action. Therefore, it is believed that a detailed discussion of the secondary references is not deemed necessary for a full and complete response to this office action. Accordingly, allowance of the claims is respectfully requested.

In conclusion, the references cited by the Examiner, neither alone nor in combination, teach, show, or suggest the method or apparatus of the present invention. Having addressed all issues set out in the office action, Applicants respectfully submit that the claims are in condition for allowance and respectfully request that the claims be allowed.

Respectfully submitted,

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## VERSION WITH MARKINGS TO SHOW CHANGES MADE

### IN THE SPECIFICATION:

Please replace paragraph **[0019]** with the following paragraph:

**[0019]** It was unexpectedly and surprising discovered by the inventors herein that depositing silicon carbide materials with an organosilicon compound having the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 0 to 3, b is 0 to 3, and c is 1 to 4, under the processing parameters described herein, produced a silicon carbide film having a dielectric constant of less than 4 with improved barrier layer properties, such as an interlayer diffusion resistance of about 100% greater than silicon carbide film produced by commercially available alkylsilane precursors, such as trimethylsilane (TMS). This is unexpected because it has been observed that phenyl groups increase the porosity of the deposited dielectric material, thereby reducing the interlayer diffusion resistance of the deposited dielectric material. The barrier layers are preferably deposited adjacent dielectric layers comprising silicon, oxygen, <u>and carbon,</u> which have a dielectric layer of less than about 3.

Please replace paragraph **[0024]** with the following paragraph:

**[0024]** The barrier layer may further be doped with oxygen, <u>nitrogen,</u> boron, or phosphorous to reduce the dielectric constant of the deposited material. A ratio of dopant to organosilicon compound in the processing gas is between about 1:5 or greater, such as between about 1:5 and about 1:100. Phosphorus and/or boron doping of the low k silicon carbide layer may be performed by introducing phosphine ($PH_3$) or borane ($BH_3$), or borane derivative thereof, such as diborane ($B_2H_6$), into the chamber during the deposition process.

### IN THE CLAIMS:

1. (Amended) A method for processing a substrate, comprising:

depositing a barrier layer on the substrate by introducing a processing gas comprising an organosilicon compound into a processing chamber, wherein the organosilicon compound has the formula [$SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 0 to 3, b is 0 to 3, and c is 1 to 4,] $\underline{SiH_a(CH_3)_b(C_6H_5)_c}$, wherein a is 1 or 2, b is 1 or 2, and c is 1 or 2, and reacting the processing gas to deposit the barrier layer, wherein the barrier layer has a dielectric constant less than 4; and

depositing a first dielectric layer adjacent the barrier layer, wherein the dielectric layer comprises silicon, oxygen, and carbon and has a dielectric constant of about 3 or less.

4. (Amended) The method of claim [3] 1, wherein the [dielectric layer is deposited by reacting trimethylsilane and oxygen in a plasma enhanced chemical vapor deposition technique] barrier layer is deposited under plasma conditions comprising maintaining a substrate temperature between about 0°C and about 500°C, maintaining a chamber pressure below about 500 Torr, and applying an RF power of between about 0.03 watts/$cm^2$ and about 1500 watts/$cm^2$.

5. (Amended) The method of claim [3] 1, wherein the [dielectric layer is deposited under plasma conditions comprising a high frequency RF power density from about 0.16 W/$cm^2$ to about 0.48 W/$cm^2$] barrier layer is treated with a plasma of an inert gas, a reducing gas, or combinations thereof, prior to depositing the first dielectric layer.

6. (Amended) The method of claim 1, [wherein the dielectric layer is deposited prior to depositing the barrier layer] further comprising depositing an etch stop layer on the first dielectric layer by reacting an organosilicon compound having the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 1 or 2, b is 1 or 2, and c is 1 or 2.

8. (Amended) The method of claim 1, wherein the processing gas further includes a dopant component selected from the group of an oxygen-containing compound, a nitrogen-containing compound, a boron-containing compound, a phosphorus-containing compound, and combinations thereof.

12. (Amended) The method of claim [1] 9, wherein the barrier layer comprises less than about 15 atomic percent of oxygen.

13. (Amended) A method for processing a substrate, comprising:

depositing a barrier layer on the substrate by introducing a processing gas comprising an organosilicon compound into a processing chamber, wherein the organosilicon compound has the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 1 or 2, b is 1 or 2, and c is 1 or 2, and an oxygen-containing compound, a nitrogen-containing compound, or combinations thereof, and [reacting the processing gas] generating a plasma to deposit the barrier layer, wherein the barrier layer has a dielectric constant of less than 4; and

depositing a dielectric layer adjacent the barrier layer, wherein the dielectric layer has a dielectric constant less than 4.

14. (Amended) The method of claim 13, wherein the dielectric layer comprises silicon, oxygen, and carbon, has a dielectric constant of about 3 or less, and has a carbon content between about 5 and about 30 atomic percent excluding hydrogen atoms.

16. (Amended) The method of claim [15] 13, wherein the [dielectric layer is deposited by reacting trimethylsilane and oxygen in a plasma enhanced chemical vapor deposition technique] plasma is generated under conditions comprising maintaining a substrate temperature between about 0°C and about 500°C, maintaining a chamber pressure below about 500 Torr, and applying an RF power of between about 0.03 watts/cm$^2$ and about 1500 watts/cm$^2$.

17. (Amended) The method of claim [15] 13, wherein the [dielectric layer is deposited under plasma conditions comprising a high frequency RF power density from about 0.16 W/cm$^2$ to about 0.48 W/cm$^2$] barrier layer is treated with a plasma of an inert gas, a reducing gas, or combinations thereof, prior to depositing the first dielectric layer.

18. (Amended) The method of claim 13, [wherein the dielectric layer is deposited prior to depositing the barrier layer] further comprising depositing an etch stop layer on the first dielectric layer by reacting an organosilicon compound having the formula $SiH_a(CH_3)_b(C_6H_5)_c$, wherein a is 1 or 2, b is 1 or 2, and c is 1 or 2.

20. (Amended) The method of claim 13, wherein [reacting the organosilicon compound comprises reacting the organosilicon compound with an] oxygen-containing compound is selected from the group of oxygen, ozone, a siloxane, and combinations thereof, and the nitrogen-containing compound is selected from the group of nitrogen gas, ammonia, a silazane, and combinations thereof.

22. (Amended) The method of claim 13, wherein the processing gas further includes a dopant component selected from the group of [a nitrogen-containing compound] a boron-containing compound, a phosphorus-containing compound, and combinations thereof.